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ABSTRACT

Reported are techniques used to analyze a general education program in the natural sciences at Clayton Junior College, a two-year college in Morrow, Georgia. A model identifying expected competencies and their assessment is presented, factors related to success in the program are examined, and results of the use of the model are discussed. (PB)

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Techniques Used to Analyze A General Education Program in the Natural Sciences

I. Statement of Expected Competencies and their Assessment

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Introduction

In recent years public attitudes and demands have made it necessary for those involved in the education of students to analyze the results of their efforts: to determine strengths, weaknesses, and the factors related to both. Concerns as to the effectiveness of educational programs are prevalent at all grade levels, with postsecondary education no exception. A number of colleges and universities have addressed this issue by developing "competency-based curricula"(CBC) (O'Connell and Moomaw, 1975). These curricula present performance-based models for assessment and scrutiny. Some of the techniques used in developing competency based curricula can be used to analyze educational programs not described as "competency-based." The purpose of this report is to describe how such techniques have been used to analyze a general education program in the natural sciences in a two-year college. First, the use of a model which includes a statement of expected competencies and their assessment is presented. Second, factors related to success in the program are examined, with the result of the use of the model serving as one of the factors. The model and its use are described in part one of this report.

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The study was conducted at a public two-year college in metropolitan Atlanta. One requirement in the curriculum of this college is a two-quarter laboratory science sequence in either biology, chemistry, or physics. Such a requirement is familiar in many colleges and universities. In this report, the required laboratory science sequences are referred to as the general education program in the natural sciences. The analysis of this program was conducted to determine:

1. competencies students are expected to have when they have completed the program,
2. the extent to which students have achieved the stated competencies,
3. factors related to success in the science program,
4. changes that would improve the science program.

A model which accomplished one and two above is described in the section that follows.

The Model

Because the results of the analysis of the general education program in the natural sciences would affect each faculty member in the disciplines included in the study, it was deemed essential that each be involved in the analysis process. The model to accomplish the task was therefore constructed to include each professor as well as a representative task force including four faculty representatives from biology, chemistry, and physics.

Three competency based techniques were chosen for the analysis: statement of competencies, method of assessment, and the assessment process. These are the major blocks of the "skeleton" model given in figure 1. Note that "feedback" from the assessment process affects the statement of competencies and the method of assessment so as to allow for on-going program analysis.

Each block of the model will now be described in more detail in the discussion that follows.

Statement of Competencies

The task at hand was to identify competencies students should reasonably be expected to demonstrate when they have completed the natural science sequence. A "who, what, and how" approach to the problem was used in this and other blocks of the model. Who refers to individuals most actively involved in the block of the model; what refers to the criteria that must be met; how refers to the methods used to accomplish the task.

Who. Faculty representatives from biology, chemistry, and physics served on a task force to establish the competencies.

What. Members of the task force concluded that the competencies should be common to each science discipline but should not be discipline specific.

How. Competency statements were constructed by searching the literature and through "brainstorming".

Method of Assessment

Several methods of assessment of student competence were considered by the task force after the competency statements were constructed. Finding no suitable published instrument, it was decided to construct an in-house examination, again using a who, what, and how approach.

Who. Each faculty member was involved in the development of the examination by writing items which he or she thought to be referenced to each competency.

What. The task force determined that the following criteria must be met by the assessment instrument: validity (the test measures the stated competencies), reliability (testing results are consistent under stated conditions), and efficiency (the instrument can be reasonably administered and graded within the college

framework).

How. Items were validated independently as to referenced competency by members of the task force. Ratings of each item were made as follows: acceptable, acceptable with modification, and not acceptable. All modifications were made by the task force, as was the final selection of items. The test was piloted with novice and experienced students and then subjected to item analysis.

The Assessment Process

The process of using the assessment instrument is described in the third block of the model.

Who. All students in the second quarter of their first laboratory science sequence were required to take the test.

What. The only criteria to be met by the testing process was accessibility to each eligible student.

How. The examination would be administered during the last two weeks of the quarter in the appropriate courses.

Results of Use of the Model

Results of use of the model as part of the analysis of the general education program are given in the section that follows.

Statement of Competencies

The task force developed competency statements which would require students to be able to use the scientific method and demonstrate knowledge of facts and principles in the subject area of choice. Only competencies referring to use of the scientific method are included in this study. Competence in the use of the scientific method means that students can:

1. identify problems suitable for investigation.
2. choose suitable hypotheses when given a problem.
3. select valid procedures for data collection.
4. identify accurate interpretations of data.
5. distinguish between valid and invalid implications of results.

Method of Assessment

After review of the criteria which the method of assessment must meet, an objective format (multiple-choice) was chosen. Ease of grading was a primary consideration, as was the readily available data for item analysis and factor analysis. Each faculty member submitted 25 items (five for each competency) to the task force. Over 200 items were collected for selection. Items selected for the pilot test were selected as previously described. Two equivalent forms of the test were administered both to students who had completed no science requirements and to those who had completed the requirements. Each form was administered later to over 150 experienced students. Each form of the test included 35 items. More information about the development of the instrument is available in an earlier report (Halyard and Murphy, 1978).

Items were selected for a single-form 50 item test by studying the discrimination coefficient, the difficulty of the item, and a second review of the items by the task force judges. The multiple-choice test, called the Scientific Method Assessment Test (SMAT) was reduced to 40 items by the same means. The length of the test was reduced because many students could not finish the test during the allocated 50 minute class period.

The Assessment Process

The current version of the SMAT was administered to 306 students enrolled in the second quarter of biology, chemistry, and physics. Although students

were required to take the test, their SMAT score was not included in the calculation of their final grade. The mean score was 28.07 (70.17%) with a standard deviation of 5.43. The standard error of measurement of the mean was 0.31, the reliability as estimated by Cronbach's Alpha was 0.77. These data are given in Table 1. A description of the sample is given in Table 2.

Items referenced to a particular competency comprised a subtest; the SMAT therefore included 5 subtests. Subtest data revealed very low item-test correlations; in other words, items typically correlated more with another subtest. Factor analysis likewise revealed that items loading on the same factor after orthagonal rotation were not members of the same subtest. This result is not wholly unexpected because the steps of the scientific method are intercorrelated; ability to use one step customarily requires proper use of another. This further helps obscure identification of factors.

Discussion

Students' performance on the SMAT appears favorable at first glance due to the 70 percent achievement level. No conclusions can be drawn, however, without first studying more about what SMAT is actually measuring. Reading level of the instrument is currently being studied as a possible factor in success on the SMAT. A wide range of reading levels appears possible. Ambiguous subtest data and factor analysis results further support the need to study the relationship of SMAT to other factors related to success in the program. Following such a study more decisions can be made relative to the revision of competency statements and the method of assessment.

In part two of this report, factors related to success in the natural science program (including SMAT) are discussed.

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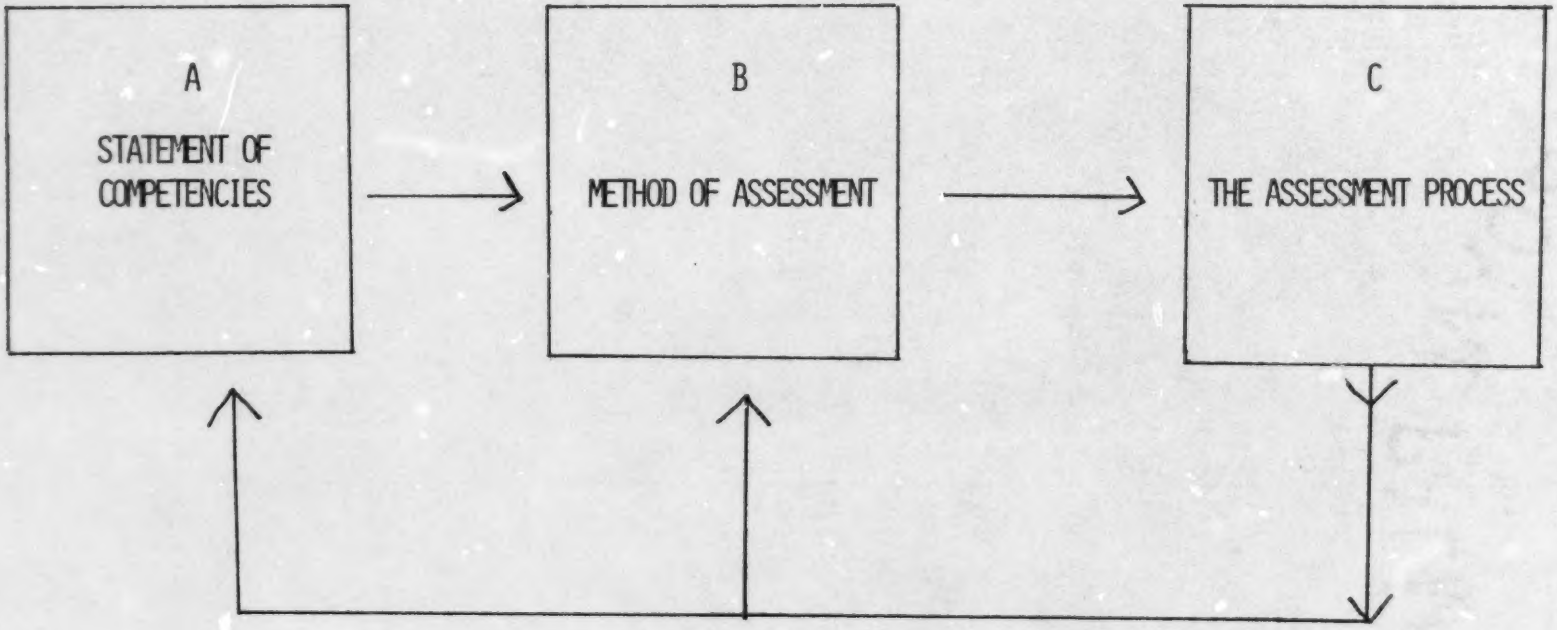

FIGURE 1. A "SKELETON" OF THE MODEL USED TO ANALYZE A GENERAL EDUCATION PROGRAM IN THE NATURAL SCIENCES.

TABLE 1

DATA FROM SMAT TEST

MEAN	28.07
STANDARD DEVIATION	5.43
$S.E._{MEAN}$	0.31
RANGE	12-39
CRONBACH'S ALPHA	0.77
RANGE OF ITEM DIFFICULTY	0.08-0.81

NOTE: N=306

TABLE 2

DESCRIPTION OF SAMPLE USED IN THE ASSESSMENT PROCESS

	MEAN	STANDARD DEVIATION	SCALE
SCIENCE HOURS	10.57	3.74	ACTUAL (QUARTER)
AGE	23.14	6.33	ACTUAL (YEAR)
NON-LAB SCIENCE	0.65	1.69	0,5 (QUARTER HOURS)
COURSE GRADE	2.06	1.12	0-4.0
COLLEGE HOURS	54.21	24.31	ACTUAL (QUARTER)
COLLEGE GPA	2.35	0.70	0-40
COLLEGE MATH	6.52	6.38	ACTUAL (QUARTER HOURS)

NOTE: N=306